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Irrigation distribution automatization based on scheduling system

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Abstract. Paddy fields become areas of rice cultivation, which considered as one of the staple foods for Indonesians. Limited availability of water for irrigating requires regulation of water distribution for each field area. The area of irrigated rice fields that are not proportional to the available of water discharge triggers conflict potential among farmers. Currently, the water distribution is supervised by P3A (Association of Water User Farmers) officers. However, several problems are still around, for example the injustice of the distribution process and water corruption committed by farmers who violate the distribution rules. These matters cause the farmers to have some extra guards at night, and may contribute to social conflict and crop failure in the future. This study designed a system as an instrument to distribute water on a scheduled basis in accordance with the agreement of farmer groups. The system is developed by using Arduino Mega 2560 Microcontroller which is equipped with water level sensors (height) and water moisture sensor (humidity). The system was successfully designed by using two valves as the irrigation door on two fields. In the scheduling process in each of four conditions where the instrument was tested, the tool was proven that able to work within the schedule with 100% success rate, as well as the experiment result of water level stability.

1. Introduction

Forty percent regions in Indonesia are still rely on rainwater as the irrigation sources [1]. The rain-fed type of paddy fields is always depending on the weather that is typically unpredictable. In addition, paddy fields also have limitation in the frequency of planting. Efforts in water utilization through irrigation require improvements so that it can be implemented effectively and efficiently for a better management system [2]. Currently, In Indonesia, the water distribution is supervised by P3A (Association of Water User Farmers) officers. Irrigation is aimed to facilitate the farmers in the process of plant watering especially for type of plants that needs plenty of water supply. If the water shortages during the process of planting, crop failure or decreasing stock of food are potentially happened. By the time it raises the market price, consumers' purchasing and food security may be badly affected. Limited availability of water for irrigating requires regulation of water distribution for each field area. The area of irrigated rice fields that are not proportional to the available of water discharge triggers conflict potential among farmers within the irrigation unions [2][3][4]. Social



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conflicts among farmers are very likely to happen due to the clash of irrigation shifts [5]. The seizure of water also occurs due to the difference in demand between pool owners and rice farmers as well as triggering the conflict. One solution to be proposed for the root of this problem is the allocation of irrigation. This research exploits Arduino Mega 2560-based scheduling method which is combined with water level sensor and soil moisture sensor. The scheduling system works under a setting schedules and protected by the water level sensor.

2. Research Methods

The first step to do is designing a flowchart as a guide for operating the system, as seen in Figure 1.

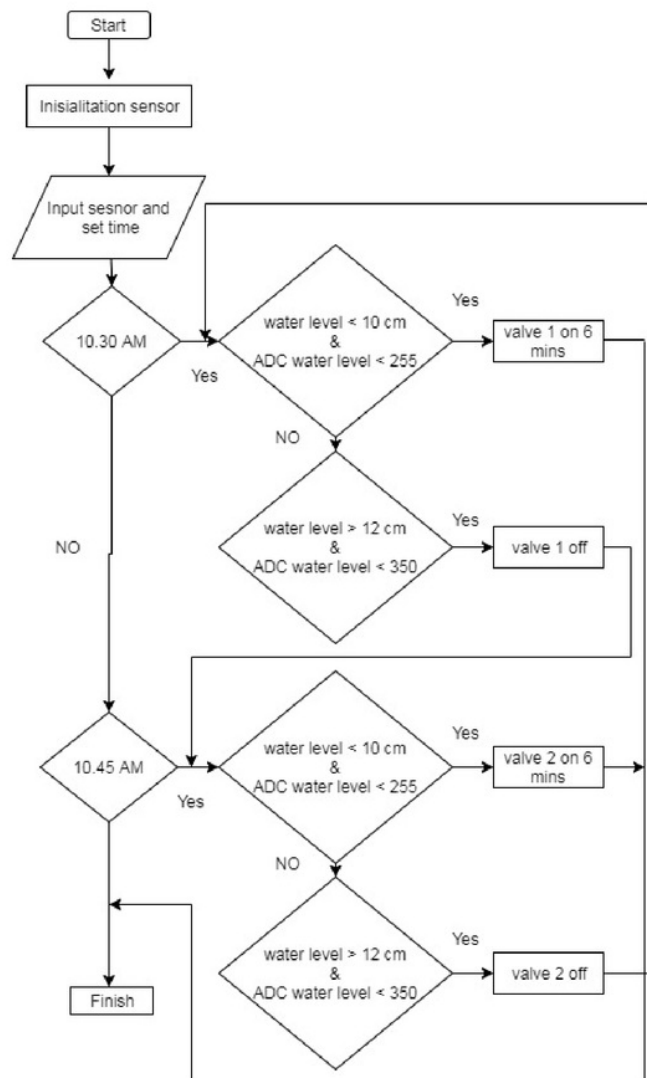


Figure 1. Flowchart of Irrigation Distribution Automatization Based on Scheduling System

As depicted in the flowchart above, the process starts from initialize the sensor to the execution process using a 12V DC motor actuator. This tool works using a scheduling system that has been agreed by the users over two paddy fields with different schedules. In the evening at 10:30 am until 10:45 am, system has ready to check water volume on paddy fields. The System can be activated less than 10 cm water level or ADC values of 255 byte on motor DC that process to open valve among 6 minute. Furthermore, the valves close and system turn-off are sensors detected too high (more than 12 cm) . That system process work is cycled in everyday by default schedules.

3. Result of Research Data

Results obtained from 8 (eight) experimental studies by observing ADC values on water level sensors and digital multimeters are listed in Table 1.

Table 1. Data of voltage and ADC value of water level sensor

Experiment	Plot Number	Water Level		Result (volt)	Difference
		ADC	Volt		
1	1	425	0,67	0,78	0,11
2	2	451	0,52	0,64	0,12
3	1	429	0,63	0,74	0,11
4	2	393	1,07	1,13	0,06
5	1	397	1,03	1,09	0,06
6	2	389	1,10	1,16	0,06
7	1	362	1,16	1,21	0,05
8	2	374	1,15	1,19	0,04

Table 1 shows the readings of ADC values and voltage on the water level sensor after 8 times of experiments have successfully conducted into 2 plots of rice fields; plot number 1 and plot number 2. The result of voltage used as a comparison with the measurement results to obtain the value of difference. These experiments from all plots resulted in several assessments, such as the percentage of error value and accuracy on time settings and water level sensors, which can be seen in Table 2.

Table 2. The overall data

NO	Swath	Condition Beginning		Setting (Time)	Start (Time)	Under Limit (cm/mins)	Upper Limit (cm/mins)	Duration Irrigation Swath (mins)	Finish	Error %	Accuracy %
		setting	real								
1	1	0	0	10:30	10:30	10/5	12,5/6	10 mins	10:40:00	0	100
2	2	0	0	10:41	10:41	10/5	12,5/6	10 mins	10:51:00	0	100
3	1	1	1	10:52	10:52	0	0	10 mins	11:02:00	0	100
4	2	1	1	11:03	11:03	0	0	10 mins	11:13:00	0	100
5	1	0	0	11:14	11:14	10/5	12,5/6	10 mins	11:24:00	0	100
6	2	1	1	11:25	11:25	0	0	10 mins	11:35:00	0	100
7	1	1	1	11:36	11:36	0	0	10 mins	15:46:00	0	100
8	2	0	0	11:47	11:47	10/5	12,5/6	10 mins	15:47:00	0	100

From the observation result reported in Table 2, it is found that the error percentage value at the initial condition of setting and real during 8 experiments on each plot obtained by the following error rate:

$$\begin{aligned}
 \text{Error (\%)} &= \frac{\text{setting-error}}{\text{setting}} \times 100\% \\
 &= \frac{8-8}{8} \times 100\% \\
 &= 0\%
 \end{aligned}
 \tag{1}$$

Error value is the total of similarities between the setting and the real throughout 8 experiments. The following calculation from Equation (1) obtained error rate of 0%, or in other words, the level of accuracy of water level in all plots despite of all conditions reached 100% rate of success. The accuracy level of irrigation distribution scheduling on all plots in all conditions gained perfect score, since the setting time and start time have no differences.

3.1. Graphical Data

Figure 2 visualizes the difference points between the measurement and calculation of voltages as listed in Table 1.

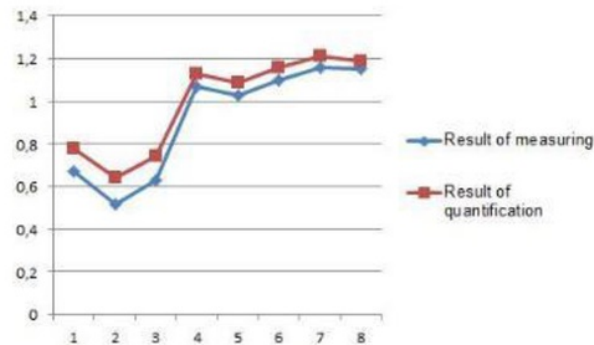


Figure 2. Comparison between result of voltage measurement and calculation

In figure 2 is showed consist test of 8 measurement, red line and blue line that describes of different testing methods both lower and highest voltage by multimeter. It is explain deviation of value each testing. By the graphic that used for check performance of system which is made a robust system.

4. Results and Analysis

The process of data retrieval in this study starts from the installation of all tools and sensors to be used, as portrayed in Figure 3 and Figure 4.



Figure 3. Installation of tools



Figure 4. Installation of sensors

The system can be executed after all the tools and sensors are installed. The process of opening the valve towards the paddy fields based on the scheduled system can be represented in Figure 5.



Figure 5. The process of opening the valve on the rice field (1) on schedule

After the process of valve opening is started, it then continued with the data collection process of each sensor, i.e. water level sensor. The ADC current value condition shown on the monitor serial was 425, while the output voltage signal was 0.78 VDC by using (2) and (3) methods [10].

$$ADC\ data = \frac{5V}{521} = 0.009\ V \quad (2)$$

The 5V value is the output voltage of Arduino Mega 2560 which is divided by the maximal value of ADC at the water level sensor, that is 512. The result is 0,009 V / 1 ADC.

$$V_{out} = 512 - 425 = 83 \times 0.009 = 0.78\ VDC \quad (3)$$

The value of ADC equals 512, which is the maximum value of the water level sensor. While the value of ADC equals 425, that is obtained from the actual condition of the water level sensor multiplied by the value per 1 ADC which equals 0.009. Therefore, the output voltage signal obtained 0.78 VDC, which means that the water flows in the paddy field is in a good condition, not less than 10 cm and no more than 12 cm above the soil surface. The actual condition results show the difference 0.11 VDC of the measurement result if using a multimeter. Soil moisture sensor test used to compare the measurement results read on Arduino Mega 2560 with the measurement result of the digital multimeter. The results can be seen in Figure 6.



Figure 6. Display of moisture sensor on 16x2cm screen of LCD and multimeter

The ADC value condition shown on the serial monitor is 25, then the output voltage signal is obtained as 1.01 VDC by using methods (4), (5) and (6) [11].

$$ADC\ data = \frac{4,12}{1023} = 0.0040273705\ V \quad (4)$$

The value of 4.12 is the output voltage of Arduino Mega 2560, which is divided by the maximum value of ADC towards soil moisture sensor, that is 1023. It then resulted in 0,0040273705 VDC / 1 ADC.

This study uses the condition of ADC value where it is divided by 10 points, so that the scale of ADC value will be transformed into the range of 0-102, causes the reading is written as follows:

$$Condition = \frac{1023}{10} \quad (5)$$

The output voltage signal from ADC value as follows:

$$Vout = 1023 - (77 \times 10) = 253 \times 0.00402 = 1.017\ VDC \quad (6)$$

Value of 77 is the result of the maximum scale of the ADC, which is subtracted over the actual conditions score of the rice field. The value of 10 is the multiplier factor so that the ADC value scale is in range of 0-1023. The value of 1023 is the ADC value in 10 binary bits, which resulted in 253 points. The ADC value equals 25 is obtained from the output voltage signal of 1.01 VDC which means that the soil condition is wet as the ADC value < 50. Scores of actual conditions show differences from measurement results by using a digital multimeter which is 0.04 VDC.

5. Conclusion

Based on the observations, the average accuracy of the water distribution scheduling by applying this tool was 100% rate of success, so it can be concluded that the proposed tool works optimally. It is hoped that this automation tool can assist the Water User Farmers Empowerment (P3A) officers in distributing water through the irrigation door. Moreover, this tool hopefully can reduce conflict between farmers about water distribution issues. The accuracy of the water level in the field reached 87.5%. While mistakes previously occurred due to several factors such as inconsistent water discharge, less optimal valve openings, which caused the water level was inaccurate.

6. References

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